CHAPTER 2 ENERGY, THE ECONOMY, AND THE ENVIRONMENT

Energy is one of the key factors shaping Hawaii's standard of living, economy, and environment. This section briefly examines the benefits of energy and the interrelationships between energy, the economy, and the environment.

2.1 The Need for Energy

Energy is essential to modern life. Hawaii's citizens use energy for transportation, hot water, refrigeration, heating, air conditioning, ventilation, lighting, cooking, operating office and industrial machines, running appliances, and for other essential uses. Hawaii's people use less energy per capita than the citizens of any other state, except New York, primarily because of Hawaii's comfortable climate and short driving distances. Hawaii's total energy use per capita ranked 50th of the states and District of Columbia in 1995 (EIA 1997, 18).

2.2 Energy and Hawaii's Economy

2.2.1 Energy for Economic Activity

Energy is the power behind Hawaii's economy. Energy is used by the jets carrying visitors and residents to and among the islands. It takes energy to provide the ground transportation, air conditioning, hot water, and lights to make visitors' stay more comfortable. Energy supports Hawaii's military installations and the military's Hawaii-based operations. Energy is used to produce Hawaii's sugar and other agricultural products. Energy lights Hawaii's stores, refrigerates and cooks food, and provides myriad other services. Energy use by Hawaii's residents is a major component of economic activity, and energy-related companies make up a large segment of Hawaii's economy. Hawaii's top 15 energy companies had sales of $2.7 billion in 1998. The four electric utilities and the gas utility had sales of $1.1 billion. Hawaii's two refining oil companies had sales of over $1 billion. Combined, the companies listed above employed over 4,000 people.

Due to a number of factors, Hawaii's economy is overly dependent on oil. Oil is easy to transport, and an oil-based infrastructure has evolved in Hawaii over the years. The system is supported by historically low real oil prices.

The system requires massive exports of money to pay for imports of crude oil and some refined products. This money is not used for further development of Hawaii's economy and does not have local multiplier effects. Much of Hawaii's energy demand is inelastic, so that when energy prices rise, even more money is diverted from other sectors of the economy to meet energy needs. In addition, Hawaii's own renewable resources are not fully used, and additional energy efficiency measures could be adopted.

Renewable energy and energy efficiency offer the economic benefits of keeping money in the State and providing greater levels of employment per unit of energy. Greater local employment would result in multiplier effects that would enhance the local economy. Numerous studies have found that greater use of energy efficiency measures and renewable energy result in more jobs, higher personal income, and slightly higher economic output than the fossil-fuel base case.[1] Energy efficiency reduces bills paid by consumers and businesses, who can then shift their spending to sectors that employ more workers per dollar received (Geller 1992, III). This could increase employment in Hawaii and keep money in the State's economy that otherwise would have gone abroad to pay for fossil fuel.

2.2.2 The High Costs of Energy to the Economy

Total energy expenditures in Hawaii amounted to $2.76 billion in 1997 (the latest year for which sufficient data were available), or about 8% of the gross state product (GSP) in 1997 dollars. This was an average of $2,323 per capita (DBEDT 1999). Hawaii's energy costs are detailed in Section 3.1.2.1.

Based upon the components in the 1996 U.S. Bureau of Labor Statistics Honolulu Consumer Price Index, electricity accounted for 2.18% of the average Honolulu resident's expenditures; 0.18% was expended on utility gas; and 3.02% was spent on motor fuel. Together these costs represented 5.38% of total consumer expenditures (DBEDT 1998e, 388–389).

2.2.3 The Economic Risks in Hawaii's Current Energy System

Hawaii's residents and visitors use oil to meet 90% of their energy needs. Hawaii's dependence on oil poses risks to Hawaii's economy from sudden price increases or from supply problems as were experienced in 1973, 1979, 1991, and 1992. In the 1995 *Hawaii Energy Strategy* (*HES 1995*), an oil price spike scenario was modeled based upon a scenario in which oil prices increased from a 1996 cost of $19.42 per barrel to $45.00 per barrel for a one-year period, after which they dropped back to normal levels. The scenario was based upon the actual oil price spike of 1979. Based on runs in the ENERGY 2020 model, this scenario produced considerable short-term economic dislocation. Employment dropped 2%, or around 15,000 jobs and took two years to regain former levels. Gross state product dropped by $791 million in the spike year and was down $271 million the following year. Personal income dropped $1.18 billion in the spike year (DBEDT 1995a, Appendix 2-2 to 2-3).

While oil prices in early 1999 were at historic lows on an inflation-adjusted basis compared with 1973, they rose sharply beginning in March, and the possibility of a disruption of oil supplies and oil markets due to armed conflict or political action remains. This will be discussed in more detail in Chapter 3.

[1] See Bernow 1999; Clemmer 1994; Geller 1992; Hamrin 1993; Laitner 1994; Loudat 1995; Marshall 1995; Pacific International Center for High Technology Research 1994; State of Missouri 1992; State of Vermont 1997.

2.3 The Links between Hawaii's Energy Use, the Economy, and the Environment

Hawaii enjoys a beautiful natural environment that provides pleasant living conditions for residents, and many regard it as paradise. Hawaii's economy is based upon its beautiful environment, and the environment is the major reason tourists come to the Islands. The challenge is to protect Hawaii's environment while meeting the energy needs of Hawaii's people for jobs, income, and a growing economy.

Over the long term, energy use in Hawaii degrades air quality, poses risks of water and land pollution, and is Hawaii's major human-caused contribution to greenhouse gas emissions that contribute to global climate change. The most serious immediate threat to both Hawaii's environment and economy is the small but real potential for a large oil spill and damage to beaches and the tourism industry.

2.3.1 The Oil Spill Threat

Transportation of oil and oil products poses the constant risk of a spill, with subsequent damage to the environment and the economy. In 1997, almost 51 million barrels of crude oil and another 6.6 million barrels of refined oil products were imported into Hawaii by sea, mainly via Barbers Point, Oahu. The crude oil was offloaded from tankers at separate offshore moorings at Barbers Point operated by Chevron USA Hawaii and Tesoro Hawaii. In addition, 9 million barrels of refined products were shipped by barge from Oahu to neighbor islands (DBEDT 1999). Ships carrying oil as fuel also pose an oil spill risk. On Oahu, large quantities of petroleum products are transported via pipelines, which have suffered accidental leaks in the past. Transportation of petroleum products on all islands by tanker truck poses the further risk of accidental spills.

Following the *Exxon Valdez* disaster in Alaska in 1989, the State of Hawaii Department of Health commissioned a study by the University of Hawaii Sea Grant College Program of the potential impacts of oil spills at sea on Hawaii. Dr. Rose Pfund led the study and edited the final report, *Oil Spills at Sea, Potential Impacts on Hawaii* (Pfund 1991). The study evaluated a worst-case scenario, developed by the U.S. Coast Guard, in which a tanker lost one-third of its cargo, or 9.8 million gallons (233,000 barrels), in the Kaiwi Channel, then the primary route used by tankers en route to Oahu. The oil then washed up on Oahu and Kauai (6).

The economic costs would have been huge for such a spill. Cleanup costs alone would have been $210 to $305 million (35). It was estimated that oil washed up on the beaches of Oahu would result in a 32% reduction in tourism in the first year and a $3.06 billion loss in revenues to the tourism industry (57). Oahu's beaches and coral reefs would also have suffered severe environmental damage, and wildlife would have been killed in large numbers (69).

As a result of the study, tanker operators agreed to use the wider Kauai Channel, to reduce the risk of collision and to provide more maneuvering space in event of mechanical malfunction. Soon thereafter, in reaction to the *Exxon Valdez* disaster, the Federal Oil Pollution Act of 1990 set up a planning and command structure emphasizing oil spill prevention and a response structure. Additional liability was placed on tanker operators as a strong incentive to increase safety. Hawaii's spill-prevention efforts and preparedness to deal with spills were enhanced (Rappa 1996, 20).

Hawaii's readiness to handle an oil spill was enhanced by the creation of the Clean Islands Council and the purchase of spill-response ships and equipment. The State recently acquired an aerial oil-dispersant application system that can be used by Hawaii Air National Guard C-130 transport aircraft. In addition, the State and the U.S. Coast Guard negotiated a memorandum of understanding that would allow in-situ burning of oil spills at sea (Munger 1999a, 4-5), a technique that has seen successful application elsewhere.

Hawaii remains vulnerable to oil spills. The offshore terminals are well managed, but human error or mechanical failure could lead to a major spill (22). For example, the *Exxon Houston* grounded near Barbers Point a few years ago. Through hard work and luck the ship was saved, and the loss of its 3.8 million gallons (90,000 barrels) of crude oil and its bunker fuel was prevented (24).

Further risks are posed to the environment when products refined in Hawaii, such as high-sulfur fuel oil and naphtha, are exported. While air pollution control regulations restrict the use of high-sulfur fuel oil to ships, naphtha is used to produce synthetic natural gas (SNG) and can be used as a fuel for combustion turbines. Increased SNG use on Oahu could reduce the spill risks from export shipments.

2.3.2 Energy Use and Air Quality

Hawaii's air quality meets federal and state environmental health standards because Hawaii's trade winds and the lack of major polluting industries reduce the buildup of air pollution over the islands (Juvik 1998, 297). Most emissions from energy use are highly regulated by Federal and State laws.

Under the Clean Air Act, the United States Environmental Protection Agency set National Ambient Air Quality Standards (NAAQS) for a variety of "criteria pollutants." These include ground-level ozone, nitrogen dioxide (NO_2), particles less than 10 microns in diameter (PM10), sulfur dioxide (SO_2), carbon monoxide (CO), and lead (ERG 1997, 5-1 to 5-2). The State Health Department has set standards that are up to twice as stringent as the EPA criteria for most of the criteria pollutants (5-2).

The Hawaiian Electric Company's (HECO) externality study, *Hawaii Externalities Workbook* (HECO 1997b), analyzed the effects of the criteria pollutants and other air pollutants in Hawaii. Damages were estimated by quantifying emissions, determining ambient concentrations, identifying exposure to determine physical effects, and finally, monetizing damages (5-8). Effects evaluated included mortality, morbidity, materials damages, and reduction of visibility (5-16). As effects were specific to type of generator and its location, the calculation of monetary damages was necessarily complex. Damages from three types of pollutants were monetized. The mid-range values, without adjustment for the $43 per ton emission fee currently paid to the Department of Health, were as depicted in Table 2.1. The HECO utilities did not provide an externality value for greenhouse gases.

These values were intended for use in quantifying the costs of power plant air emissions in selecting among resource options for future fossil fuel generation. They demonstrate that air emissions that meet federal and State standards do have external costs that affect Hawaii's environment and economy.

Table 2.1 Mid-Range Estimated Damages from Air Pollutants Without Adjustment for Emission Fees

Pollutant	HECO	MECO	HELCO
Damages in Dollars Per Ton			
NO_x	$ 9.95	$ 5.28	$ 2.12
SO_2	$ 20.52	$ 10.25	$ 5.09
PM 10	$ 1,280.02	$ 706.21	$ 284.34
Damages in Cents Per KWh			
All	0.005-0.044	0.004-0.026	0.002-0.011

ERG 1997, 5-36 to 5-37

In its Integrated Resource Plan (IRP), The Gas Company (TGC) defined "externalities" as "those impacts (or benefits) of an activity that are generally not reflected in the 'internal' or direct market costs of an activity" (5-1). TGC considered environmental, energy security, macroeconomic and employment, and social and cultural externalities.

TGC placed the externalities into three categories by priority. These were:

- Greenhouse gases (CO_2, CH_4, and N_2O, etc.) that contribute to climate change;
- Criteria air pollutants as defined by the Clean Air Act (CO, NO_x, SO_2, PM10,[2] ozone, and lead);
- All other externalities resulting from gas production, transportation, and use (5-2).

TGC stated that "including reasonable values for CO_2 and CH_4 in utility planning is one way to begin to recognize climate change risks [in] Hawaii's energy decisions" (5-11). TGC evaluated a variety of values assigned by various jurisdictions for greenhouse gas emissions and criteria air pollutants and proposed the externality values depicted in Table 2.2.

[2] Particulate matter greater than or equal to 10 microns

Table 2.2 TGC's Proposed Greenhouse Gas and Air Emissions Externality Values Per Ton of Emissions

	Greenhouse Gases		Criteria Air Pollutants				
Estimate	CO_2	CH_4	NOx	SOx	PM_{10}	CO	VOC
Low	$ 10	$ 210	$ 3	$ 4	$ 162	N/A	N/A
Mid	$ 27	$ 567	$ 8,100	$ 1,913	$ 4,162	$ 1,080	$ 6,683
High	$ 77	$ 1,617	$ 18,147	$ 9,304	$ 59,668	$ 11,653	$ 8,659

TGC 1999, 5-13

In addition, it should be noted that transportation fuel emissions in Hawaii likely have greater effects, because about twice as much fuel is used for transportation as is used for electricity generation.

2.3.3 Energy Use and Water Quality

Other than the risk of oil spills, the main risk to water quality from energy uses is non-point source pollution. Recent implementation of higher standards for fuel storage tanks reduced the potential for leaks, but spills and leaks of small amounts of transportation fuels and lubricants onto pavement or earth can eventually find their way into bodies of water or into aquifers.

2.3.4 Land Impacts of Energy Use

Land use impacts of electric power facilities, transportation fueling facilities, and oil refineries are mitigated by a number of regulations and permit requirements. Aesthetic impacts can be reduced through a number of measures and are considered in the Environmental Impact Statement approval process (ERG 1997, 7-3 to 7-14). Transportation fueling facilities, oil refineries, oil terminals and pipelines, oil and coal storage facilities, and coal handling facilities also have significant land impacts.

2.3.5 Energy Use, Greenhouse Gas Emissions, and Climate Change

2.3.5.1 The Greenhouse Effect, Greenhouse Gas Emissions, and Climate Change

The earth's weather and climate are driven by energy from the sun. Water vapor, carbon dioxide, and other gases in the atmosphere trap some of the energy from the sun, creating a natural "greenhouse effect" (USEPA 1998a, 1). There is strong evidence that due to industrialization, energy use, other human activities (and population growth), greenhouse gas concentrations in the atmosphere have increased. The greenhouse gases (primarily CO_2, CH_4, N_2O, and chlorofluorocarbons) are implicated in the global warming of the earth's atmosphere.

International climate scientists of the Intergovernmental Panel on Climate Change have concluded:

- Greenhouse gas concentrations have continued to increase since pre-industrial times (about 1750);

- Human-caused aerosols can offset heat increases caused by greenhouse gases for the short-term, but greenhouse gases have long-term effects;
- Climate has changed over the past century (average temperatures have increased by 0.6 to 1.2 degrees F from today's levels), and recent years have been the warmest since 1860, when systematic recording of temperature data began;
- The balance of evidence suggests a discernible human influence on global climate;
- Climate is expected to continue to change in the future. By 2100, average surface temperatures could increase 1.6 to 6.3 degrees F. Sea level could increase 6 to 38 inches. Significant changes in air and ocean circulation patterns could significantly alter global climate and the ecological balance among species;
- There are still many uncertainties, and scientists continue to study the issues (IPCC WGI 1995, 8-13).

2.3.5.2 Climate Change and Hawaii

Honolulu's average temperature has increased by 4.4 degrees over the last century. Rainfall has decreased by about 20% over the past 90 years. By 2100, average temperatures in Hawaii could increase by 1 to 5 degrees F in all seasons and slightly more in fall. Estimates for future rainfall are highly uncertain because reliable projections of El Niño effects have yet to be made. It is possible that large precipitation increases could occur in summer and fall. It is also not yet clear how the intensity of hurricanes might be affected, but it is expected that there would be more frequent and more severe thunderstorms (USEPA 1998a, 2).

Climate Change and Human Health in Hawaii. The health of Hawaii's people may be negatively affected by climate change. Higher temperatures may lead to greater numbers of heat-related deaths and illnesses. Increased respiratory illnesses may result due to greater ground-level ozone. Increased use of air conditioning could increase power plant emissions and air pollution. Viral and bacterial contamination of fish and shellfish habitats could also cause human illness. Expansion of the habitat and infectivity of disease-carrying insects could increase the potential for malaria and dengue fever (2-3).

Climate Change, Sea Level Rise, and Hawaii. At Honolulu, Nawiliwili, and Hilo, sea level has increased 6 to 14 inches in this century and is likely to rise another 17 to 25 inches by 2100. The expected rise in sea level could cause flooding of low-lying property, loss of coastal wetlands, beach erosion, saltwater contamination of drinking water, and damage to coastal roads and bridges. During storms, coastal areas would be increasingly vulnerable to flooding (3).

Climate Change and Hawaii's Water Resources. Higher temperatures could result in increased evaporation and changes in rainfall. While increased rainfall could recharge aquifers, it could also cause flooding. As the variability of climate is expected to increase, there could also be frequent and long droughts (3).

Climate Change and Hawaii’s Agriculture and Forestry. Agriculture might be enhanced by climate change, unless droughts decrease water supplies. Forests may find adapting to climate change more difficult. For example, ‘ohi’a trees are sensitive to drought and heavy rains. Changes could disproportionately stress native tree species because non-native species are more tolerant of temperature and rainfall changes. Climatic stress on trees also makes them vulnerable to fungal and insect pests. Droughts would also increase the danger of forest fires (4).

Climate Change and Hawaii’s Ecosystems. Hawaii’s diverse environments and geographic isolation have resulted in a great variety of native species found only in Hawaii. However, 70% of U.S. extinctions of species have occurred in Hawaii, and many species are endangered. Climate change would add another threat (4). Higher temperatures could also cause coral bleaching and the death of coral reefs.

Climate Change and Hawaii’s Economy. Hawaii’s economy could also be hurt if the combination of higher temperatures, changes in weather, and the effects of sea level rise on beaches make Hawaii less attractive to visitors. Adapting to sea level rise could be very expensive, as it may necessitate the protection or relocation of coastal structures to prevent their damage or destruction.

2.3.5.3 Hawaii’s 1990 Baseline Greenhouse Gas Emissions

A 1990 baseline was established as a benchmark for Hawaii’s efforts to reduce greenhouse gas emissions. Under the Kyoto Protocol to the United Nations Framework Convention on Climate Change, signed by the United States in November 1998, the U.S. is committed to reduce its emissions by 7% less than 1990 emissions by 2008–2010. The Protocol has not been ratified by Congress, but the target provides an interim standard. Hawaii ‘s human-caused greenhouse gas emissions for the 1990 baseline year were estimated at 16,961,453 tons of CO_2, 75,717 tons of CH_4, and 680 tons of N_2O.

To allow aggregation of the effects of these three gases, their global warming potential (GWP) was calculated. GWP is a measure used to compare the relative effects of each of the different greenhouse gases on warming of the atmosphere over some future time-horizon. For such comparisons, using a 100-year time horizon, CH_4 has 22 times the radiative forcing direct impact of CO_2, and N_2O has 270 times the direct impact (USEPA 1995b, viii). The GWP of Hawaii’s 1990 emissions was 18,810,906 tons CO_2-equivalent. This was 0.3% of total U.S. emissions in 1990. While it is not expected that the national target for emissions reduction will be apportioned among the states, a 7% reduction in Hawaii’s 1990 GWP would be 17,494,143 tons CO_2-equivalent. Table 2.3 shows the components of Hawaii’s 1990 Baseline GWP by sector.

Hawaii’s energy use produced the greatest GWP in the 1990 baseline year – an estimated 16,813,006 tons CO_2-equivalent, or 89.4% of total GWP. Municipal solid waste (MSW) management and wastewater management together produced 7.4% of Hawaii’s 1990 GWP; agricultural activities emitted 2.7%; and industrial processes emitted the remaining 0.6%. For purposes of comparison, 15,636,096 tons

Table 2.3 Estimated Global Warming Potential of Hawaii Greenhouse Gas Emissions, 1990 (Tons CO_2-Equivalent)

Sector	GWP	% Total GWP	% Energy GWP
Energy Use			
Residential Sector	94,804	0.5%	1%
Commercial Sector	282,412	1.5%	2%
Industrial Sector	837,599	4.5%	5%
Electricity Sector	7,652,966	40.7%	46%
Marine Transportation	155,599	0.8%	1%
Air Transportation	3,865,711	20.6%	23%
Ground Transportation	3,923,915	20.9%	23%
Subtotal	16,813,006	89.4%	100%
Non-Energy Sources			
Oil Refining	5,214	0.03%	
Cement Production	109,274	0.6%	
MSW Management	1,366,464	7.3%	
Wastewater Treatment	22,594	0.1%	
Domestic Animals	294,096	1.6%	
Manure Management	133,232	0.7%	
Sugar Cane Burning	14,106	0.1%	
Fertilizer	52,920	0.3%	
Subtotal	1,997,900	10.6%	
Total	18,810,906	100.0%	

*Municipal solid waste

CO_2-equivalent is 7% below the 1990 level of energy sector emissions. Again, it is stressed that neither the State nor any particular sector is likely to be expected to make a “quota” reduction toward the national goal.

The emissions presented in Table 2.3 are from energy use in Hawaii only, or for overseas domestic flights and marine use. In accordance with the United Nations Framework Convention on Climate Change and USEPA guidance, emissions from overseas international air and marine transportation that was provided fuel in Hawaii were not counted. In addition, about 4% of the energy sold or distributed in Hawaii in 1990 was provided to the U.S. military. Because there is no data available concerning where this fuel was actually used, it also was not included in the estimate.

2.3.5.4 The State of Hawaii Climate Change Action Plan

Under a grant from the USEPA under the State and Local Climate Change Partners’ Program, DBEDT also completed a *Hawaii Climate Change Action Plan* (DBEDT 1998b). This work was intended to become a basis for actions to reduce Hawaii’s greenhouse gas emissions and the impact of climate change. Many of the recommendations of the *Hawaii Climate Change Action Plan* in the energy sector directly support State of Hawaii energy objectives and are also recommended in this report. Greater energy efficiency and increased use of alternative renewable energy would reduce Hawaii’s emissions. Such actions can also have positive economic and environmental effects, as discussed above.

2.3.5.5 Hawaii's Future Greenhouse Gas Emissions

Figure 2.1 shows the GWP of Hawaii's actual and forecast greenhouse gas emissions from 1990 to 2020 compared with the Kyoto Protocol target. Hawaii faces major challenges in reducing its future greenhouse gas emissions. However, should the Protocol be ratified, it is not expected that individual States will have to meet Kyoto targets independently. Nevertheless, the target is useful for comparison with Hawaii's projected future emissions to evaluate scenarios designed to reduce greenhouse gas emissions.

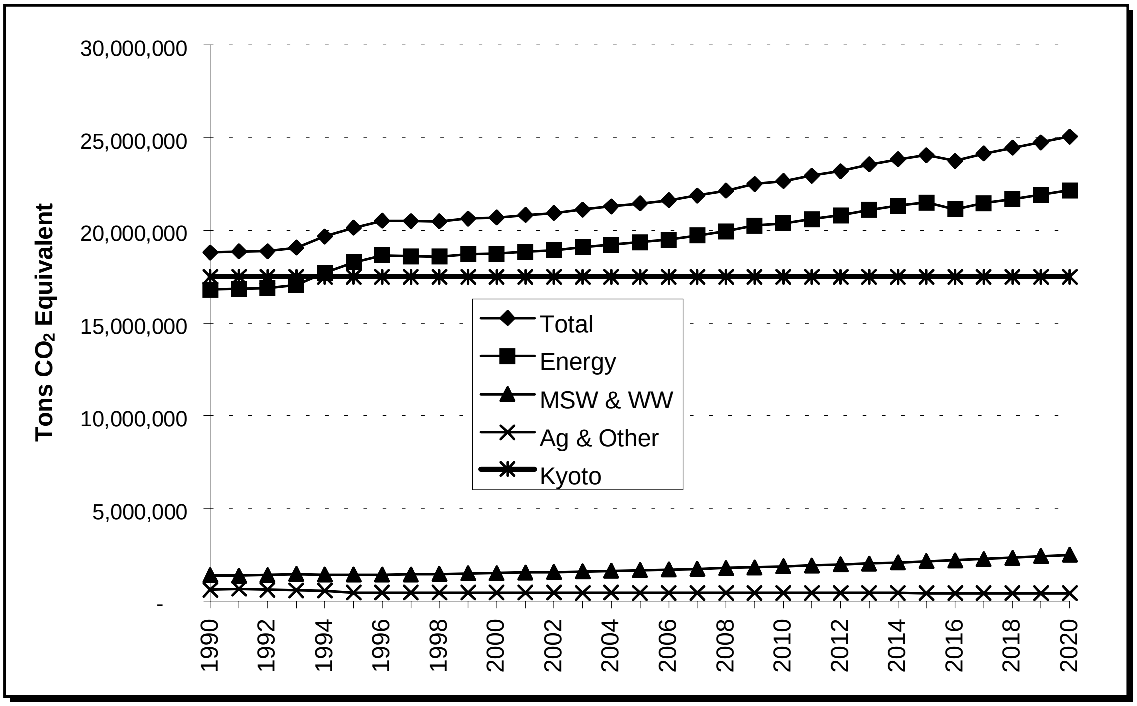

Figure 2.1 Forecast Hawaii and Domestic Overseas Energy Use Global Warming Potential and the Kyoto Protocol Target, 1990-2020

Continuing with "business as usual", Hawaii's overall domestic GWP was forecast to be 22% over the Kyoto Protocol target by 2010 and 36% over the Kyoto Protocol target by 2020. The domestic GWP from energy use was forecast to be 23% above the energy emission Kyoto Protocol target by 2010 and 32% above the target in 2020. (Note: these estimates are slightly higher than those in the *Hawaii Climate Change Action Plan* because they reflect new ENERGY 2020 model runs using new data.) Other categories shown on the chart include MSW and wastewater management (WW), which will be 34% greater than 1990 in 2010 and 79% greater by 2020, unless actions to reduce greenhouse gas emissions are taken.

"Ag & Other" includes domestic animals, manure management, fertilizer, sugarcane burning, the oil refineries, and the cement industry. Emissions are expected to decline to 30% below 1990 levels, primarily due to relatively little increase in these areas and this increase being offset by the closure of cement making operations in 1995.

In 2010, energy sector emissions were forecast to make up 90% of Hawaii's domestic GWP, followed by municipal solid waste at 8%, and agriculture and other at 2%.

2.3.6 Recommendations Related to Climate Change and Hawaii

The *Hawaii Climate Change Action Plan* offered many recommendations for reducing greenhouse gas emissions. It also pointed out the need to develop emissions reduction goals for Hawaii and the need to identify and plan adaptation measures as discussed and recommended in Chapter 1 of this report.

2.4 Balancing Energy Needs, Economic Growth, and Environmental Protection

Reduction in oil use in particular offers the opportunity to reduce the environmental risks of energy production and use, and to reduce the costs of managing those risks. Oil supplies are finite and oil prices are subject to sudden, extreme fluctuations that could devastate Hawaii's economy. Oil use poses risks to Hawaii's environment and global climate.

How might energy needs, economic growth, and environmental protection be balanced? In general, efforts to improve energy efficiency can reduce energy costs and permit businesses and consumers to spend their money in ways more productive to the local economy. In addition, by investing in alternative energy resources within the state, expenses may not necessarily be reduced, but more of the money spent will remain in the State's economy and more jobs will be created.